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Potential Impacts of Low Dissolved Oxygen on Eelgrass (*Zostera marina*) in Hood Canal

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Levels of dissolved oxygen in Hood Canal have been declining over the past several years. Since 2003, levels of dissolved oxygen are being found higher in the water column. The causes of low dissolved oxygen in Hood Canal may be a combination of the following factors: stronger stratification of seawater density layers, high organic production and respiration, slow flushing and nutrient enrichment (Newton, 2005).

A persistent decline in eelgrass areas has been seen in Hood Canal over the past 3 years (Reeves et al, 2005). Could low oxygen levels be a contributing factor to eelgrass decline in Hood Canal? A review of the current literature shows that low oxygen levels may have direct effects on eelgrass seedlings, photosynthesis, growth, and carbohydrate reserves. An increase in anaerobic respiration, a condition associated with low oxygen, can result in an increase of the end products of anaerobic respiration, including hydrogen sulfide, in the sediment porewater, decreasing the redox potential within the sediment (Goodman et al, 1995). Such changes in the redox potential have also been found to affect the photosynthesis and growth of eelgrass.

The scientific literature has shown the following possible effects of low oxygen on eelgrass seedlings: Controlled experiments demonstrate a causal relationship between sediment conditions (aerobic and anaerobic) and germination success (Hootsmans et al, 1987; Moore et al, 1993). Seed germination in anaerobic conditions is made possible because of hypocotyl elongation (Churchill, 1992) and the length of this extension may be a function of seed size (Wyllie-Echeverria et al, 2003). Consecutive hypoxic/anoxic crises may prohibit in situ flower development and seed maturation and reduce the possibility of re-colonization from the seed bank (Plus et al, 2003).

The scientific literature has shown that hypoxia and the increased presence of sulfides can negatively affect eelgrass. Rates of photosynthesis decrease during hypoxia (Holmer and Bondgaard, 2001). Anoxic root stress limits the effective transfer of carbon from shoots to roots (Zimmerman and Alberte, 1996). Photosynthesis decreased in response to increased sediment sulfide, and stopped after 6 days of high sulfide concentrations. (Goodman et al, 1995; Holmer and Bondgaard, 2001). Photosynthesis decreases oxygen translocation to the rhizosphere, which decreases the plant's ability to oxidize sulfides, further increasing sulfide levels (Goodman et al, 1995).

Eelgrass growth and carbohydrate reserves may be affected by low oxygen conditions in the following ways: Decline of animal populations in hypoxic waters may decrease grazing pressure on phytoplankton and epiphytes, thereby decreasing the light availability and hence growth of eelgrass (Duarte, 2000). The meristem of eelgrass quickly goes anoxic if water column is anoxic (Greve et al. 2003). Eelgrass leaf growth rates are significantly lower when grown in reducing sediments (Gayaldo et al, in review; Terrados, 1999). Carbohydrate reserves in roots decrease in presence of low oxygen, high sulfide levels (Holmer and Bondgaard, 2001). Low carbohydrates reserves are insufficient to support leaf growth (Zimmerman et al, 1995).

The dramatic decline of eelgrass in Hood Canal would be a drastic end result indicator of the consequences of low oxygen levels in Hood Canal. By monitoring indicators which may precede eelgrass dieoffs due to low oxygen, we may be able to predict (and prevent) the dieback of eelgrass in Hood Canal. Possible conditions to monitor would be:

- macroalgal canopies, nearshore/shallow subtidal turbidity
- seasonal carbohydrate reserves of eelgrass
- health and extent of eelgrass seed bank
- sediment redox conditions

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